Tutorial # 6. EE352

Q1 Three 100MVA single phase transformers, rated at 13.8KV : 66.4KV are to be connected in three phase Bank. Each transformer has a series impedance of 0.0045+j0.19Ω referred to its 13.8KV winding.

a) If the transformers are connected Y-Y calculate (i) the voltage and Power rating of three phase connection. (ii) the equivalent impedance as referred to its low voltage terminals. and to its high V side.

b) Repeat part (a) if transformer is connected Y on its low-voltage side and Δ on its high voltage side

Solution.

a)

i) ∵ The connected is Y-Y ⇒ then $V_{Line} = \sqrt{3}\, V_{phase}$

∴ $V_{line}(low) = \sqrt{3} \times 13.8KV = 23.9KV$.

$V_{line}(high) = \sqrt{3} \times 66.4KV = 115KV$.

$P_{3\phi} = 3 \times P_{single\ phase} = 3 \times 100 = 300MVA$.

ii)

$Z_{eq} = 0.0045 + j0.19\Omega$ (low side)

$Z_{eq} = \left(\frac{66.4}{13.8}\right)^2 (0.0045 + j0.19) = 0.104 + j4.30\Omega$ high (side)

[1]

%50

(b)

(i)

∵ The connection is Y–Δ.

$V_{Line} = V_{phase}$ (Δ connection)

∴ ~~The voltage at Δ~~ $V_{Line} = \sqrt{3}\, V_{ph}$ (Y connection)

∴ V_{Line} (Y) = 13.8 kV × √3 = 23.9 kV.

V_{Line} (Δ) = 66.4 kV.

(23.9 kV / 66.4 kV.)

$P_{3\phi} = 3 \times 100 = 300$ MVA.

(ii) ~~Zeq~~ (low side) = 0.0045 + j0.19 Ω.

Z_{eq} (high side) = $\left(\frac{66.4}{23.9}\right)^2$ (0.0045 + j0.19 Ω)

Z_{eq} (high side) = 0.0347 + j1.47 Ω

[2]

[1]

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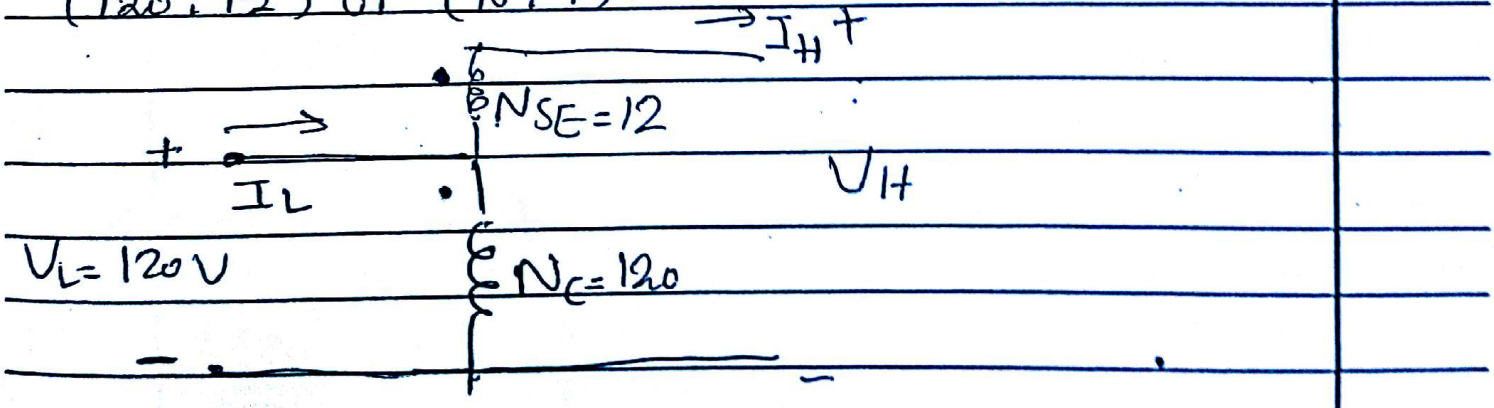
Q2 A 100 VA (120/12) V transformer is to be connected so as to form a step up autotransformer ~~See figure b~~. A primary voltage of 120 V is applied to the transformer

(a) what is the secondary voltage of the transformer?

(b) what is its Maximum voltampere rating in this mode of operation?

(c) Calculate the rating advantage of this autotransformer connection over the transformer's rating in conventional (120/12) V operation.

To accomplish a step up transforme with a 120 V primary the ratio of the turns on the common winding N_C to the turns on the series winding N_{SE} in this transformer must be (120:12) or (10:1).



(a) This transformer is being used as a step up transformer The secondary voltage is V_H.

$$V_H = \frac{N_{SE}+N_C}{N_C} \cdot V_L = \frac{12+120}{120} \cdot 120 = 132\,V$$

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(b) The maximum Voltampere rating in either winding of this transformer is 100VA. How much input or output apparent power can this provide? To find out. The voltage V_{SE} on the winding is 12V and the Voltampere rating of the winding is 100VA.

The maximum series winding current is

$$I_{SE\,max} = \frac{S_{max}}{V_{SE}} = \frac{100\,VA}{12V} = 8.33\,A.$$

Since I_{SE} is equal to the secondary current I_s or I_H and since the secondary voltage $V_s = V_H = 132V$.

$$S_{out} = V_s I_s = V_H I_H = 132 \times 8.33 = 1100\,VA = S_{in}$$

(c) The rating advantage can be calculated from Part (b) as

$$\frac{S_{IO}}{S_W} = \frac{1100\,VA}{100\,VA} = 11. \longrightarrow (1)$$

using another Method.

$$\frac{S_{IO}}{S_W} = \frac{N_{SE} + N_C}{N_{SE}} = \frac{12 + 120}{12} = \frac{132}{12} = 11.$$

The apparent power rating is increased by a factor 11

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Q3 An autotransformer is used to connect a 13.2KV distribution line to a 13.8KV distribution line. It must be capable of handling 2000KVA. There are three phases connected Y-Y with their neutrals solidly grounded.

a) What must the N_C/N_{SE} turns ratio be to accomplish this connection?

b) How much apparent power must the windings of each auto transformer handle?

Solution

a) The transformer is connected Y-Y so the primary and secondary voltages are the line voltages divided by $\sqrt{3}$. The turns ratio of each auto transformer is given by

$$\frac{V_H}{V_L} = \frac{N_C + N_{SE}}{N_C} = \frac{13.8\,KV/\sqrt{3}}{13.2\,KV/\sqrt{3}}$$

$$13.2N_C + 13.2N_{SE} = 13.8N_C$$

$$13.2N_{SE} = 0.6N_C \Rightarrow \frac{N_C}{N_{SE}} = 22.$$

b) The power advantage of this auto transformer is

$$\frac{S_{IO}}{S_W} = \frac{N_S + N_{SE}}{N_C} = \frac{N_C + 22N_C}{N_C} = 23.$$

$2\frac{1}{22}$ of the power in each transformer goes through the windings. Since $\frac{1}{3}$ of the total power is

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associated with each phase., the windings in each autotransformer must handle

$$S_W = \frac{20001KVA}{3 \times 22} = 30.3KVA.$$

Q4 A single phase 20KVA, 8000/240 volt, 60 Hz, ~~gave the following test data:~~ is to be used as an auto-transformer to supply a load at 8000 V from a 8240 V supply, find:-

a) Draw connection of the auto-transformer,

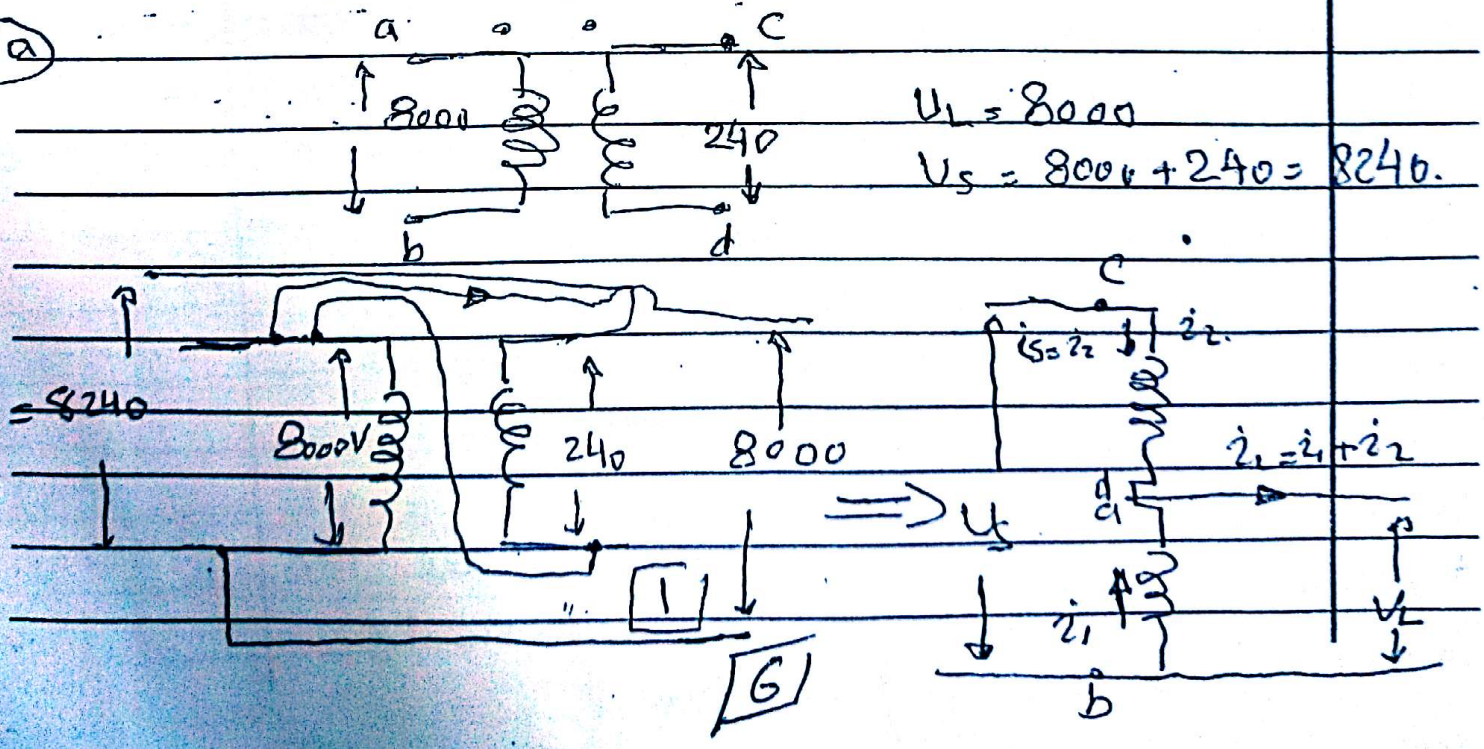
b) The rating of the auto-transformer.

c) The efficiency of the auto-transformer at its rated load 0.8 p.f.

d) The efficiency of the auto-transformer at half its rated load, 0.8 p.f. ($P_{c.u} = 240$, $P_{iron} = 490$).

Solution

a)



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(b) The rating of auto-transformer is.

$S_a = V_s i_s = 8240 \times 83.3 = 686.392 KVA.$

$S_a = V_L \cdot i_L = 8000 \times (83.3 + 2.5) = 686.4 KVA.$

(c) The losses within auto-transformer are equal to the losses occuring within two winding transformer.

$$\eta = \frac{n S P F}{n S_a + P_F + P_o + n^2 P_{s.c}} \times 100$$

$n = 1 \quad \eta_1 = \frac{1 \times 686.4 \times 0.8}{1 \times 686.4 \times 0.8 + 0.4 + 0.24} \times 100 = 99.8\%$

$n = 0.5 \quad \eta_2 = \frac{0.5 \times 686.4 \times 0.8}{0.5 \times 686.4 \times 0.8 + 0.4 + 0.5^2 (0.24)} \times 100 = 99.8\%$

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